

**Patent claims:**

1. Bone formation agent of porous calcium phosphate having an isotropic sintered structure and, between the sintered particles of the calcium phosphate, statistically distributed pores in a plurality of discrete size ranges, **characterised in that** it has a porosity composed of at least two discrete pore size distributions (I) and (II), the porosity has an irregular geometric shape, the sintered particles of the calcium phosphate have a particle size smaller than 63  $\mu\text{m}$  with a  $d_{50}$  value in the range from 5 to 20  $\mu\text{m}$ , and the interconnecting pore share in the porosity is limited to pore sizes less than 10  $\mu\text{m}$ .
2. Bone formation agent according to claim 1, **characterised in that** the maxima of the two discrete pore size distributions (I) and (II) are at pore diameters in the range from 0.5 to 10  $\mu\text{m}$  (I) and 10 to 100  $\mu\text{m}$  (II).
3. Bone formation agent according to claim 1, **characterised in that** it has preferably three discrete ranges of pore sizes (I) to (III), which are statistically distributed in terms of their size, and the maxima of the three discrete pore size distributions are at pore diameters in the ranges from 0.5 to 10  $\mu\text{m}$  (I), 10 to 100  $\mu\text{m}$  (II) and 100 to 5000  $\mu\text{m}$  (III).
4. Bone formation agent according to claim 1 to 3, **characterised in that** the volume shares of the discrete pore size distributions (I) to (III) are in the range from 20 to 40 % by volume for pore size distribution (I), in the range from 5 to 40 % by volume for pore size distribution (II) and in the range from 1 to 40 % by volume for pore size distribution (III), the overall porosity not exceeding a figure of 85 % by volume.
5. Bone formation agent according to claim 1 to 4, **characterised in that** the calcium phosphate consists to a substantial extent, and especially to an extent of at least 95 %, of alpha-tricalcium phosphate, beta-tricalcium phosphate, octacalcium phosphate, alkali metal-modified and/or alkaline earth metal-modified tricalcium phosphate, calcium diphosphate, carbonate apatite of type B, calcium-deficient hydroxyapatite or mixtures thereof.
6. Bone formation agent according to claim 1 to 5, **characterised in that** the calcium phosphate consists preferably of beta-tricalcium phosphate having a phase purity of  $\geq 99$  % by weight, relative to the foreign hydroxyapatite phase.

7. Bone formation agent according to claim 1 to 6, **characterised in that** it is in the form of a granulate and is present in various granulate fractions in a size range between 50 and 10000  $\mu\text{m}$ .
8. Bone formation agent according to claim 7, **characterised in that** the granulate has a substantially non-uniform geometric shape.
9. Bone formation agent according to claim 7, **characterised in that** the granulate has a substantially uniform geometric shape.
10. Bone formation agent according to claim 9, **characterised in that** the granulate has a substantially spherical shape.
11. Bone formation agent according to claim 7 to 10, **characterised in that** the maxima of the discrete pore size distributions (II) or (III) are matched to the granulate size.
12. Bone formation agent according to claim 11, **characterised in that** the maxima of the discrete pore size distributions (II) or (III) are a figure less than half the average granulate size of a granulate fraction and are preferably in a range between 10 and 50 % of the average granulate size of a granulate fraction.
13. Bone formation agent according to claim 1, **characterised in that** it is in the form of a shaped body having a defined geometric design.
14. Bone formation agent according to claim 13, **characterised in that** in addition to a statistical porosity it has a defined porosity in the form of tubular pores.
15. Bone formation agent according to claim 13 and 14, **characterised in that** the defined tubular porosity is formed by one-, two- or three-dimensional bores, introduced by machining, in the diameter range from 0.5 to 2 mm, and the overall porosity consisting of statistical and tubular porosity does not exceed a value of 85 % by volume.
16. Bone formation agent according to claim 13 to 15, **characterised in that** the compact shaped body has a pore size distribution graduated in size and volume share from the periphery to the core, with preferably in the peripheral zone pore size distributions (I) and/or (II) being present especially with an overall porosity of up to 35 % by volume and in the core zone pore size distributions (I) and/or (II) and/or (III) being present especially

up to an overall porosity of 85 % by volume, with the peripheral zone having a range from 10 % to 40 % and the core zone from 60 % to 90 % of the largest dimension of the implant perpendicular to the tensile stress direction or parallel to the bending stress.

17. Bone formation agent according to one of claims 1 to 16, **characterised in that** it has, on its surface and/or in its internal pore structure, antibacterial, wound healing-promoting, bone growth-promoting and/or anticoagulant substances in suitable effective concentrations.
18. Bone formation agent according to one of claims 13 to 17, **characterised in that** it has a shape individually made for a particular patient.
19. Bone formation agent according to one of claims 13 to 18, **characterised in that** it is present in standardised dimensions and shapes, preferably in the form of a cube, cuboid, cylinder or wedge.
20. Bone formation agent according to one of claims 13 to 18, **characterised in that** it has an indication-related shape, preferably in the form of a trepanation closure, alveolar augmentation or filler for cages for vertebrae replacement.
21. Method of producing a bone formation agent consisting of calcium phosphate having an isotropic sintered structure and statistically distributed pores in a plurality of discrete size distributions by way of the synthesis route of a thermally induced solid-state reaction beginning with starting materials and porosity-causing agents that are known *per se*, their homogeneous mixing and sintering, **characterised in that** a calcium phosphate is synthesised from its starting raw materials, the calcium phosphate is subsequently comminuted and a proportion of its unreacted starting materials in a stoichiometric ratio is added, the mixture is intensively homogenised and subsequently at least two porosity-causing agents that can be burnt off are added in amounts and particle distributions such that in each case they increase or produce the share of one of the two desired discrete pore size distributions, the calcium phosphate constituents are homogenised together with the fractions of the porosity-causing agents that can be burnt off, without further comminution, and are subsequently compacted, the porosity-causing agents are removed by heating, the porous non-fired calcium phosphate bodies are heated to reaction/sintering temperature for a requisite time, the porous sintered bodies are subsequently cooled down to room temperature and brought into the desired form of a granulate or shaped part.

22. Method according to claim 21, **characterised in that** to the mixture of the synthesised calcium phosphate with the proportion of its unreacted starting materials in a stoichiometric ratio there are added preferably three porosity-causing agents in such a manner that in each case they increase or produce the share of one of the three desired discrete pore size distributions.
23. Method according to claims 21 and 22, **characterised in that** to the synthesised starting material (C) there is added a proportion of the mixture of its unreacted starting materials (A) and (B) in a molar ratio of 1:2 and at least two further porosity-causing agents that can be burnt off, in amounts and particle distributions such that in each case they increase or produce the share of one of the two desired discrete pore size distributions, the mixture is homogenised without further comminution and compacted, the porosity-causing agents are removed by heating, and the material is sintered to form a porous body.
24. Method according to claim 21 to 23, **characterised in that** to the synthesised starting material (C) there is added a proportion of the mixture of its unreacted starting materials (A) and (B) in a molar ratio of 1:2 and preferably three further porosity-causing agents that can be burnt off, in amounts and particle distributions such that in each case they increase or produce the share of one of the three desired discrete pore size distributions, the mixture is homogenised without further comminution and compacted, the porosity-causing agents are removed by heating, and the material is sintered to form a porous body.
25. Method according to claim 23 and 24, **characterised in that** to the synthesised starting material (C) there is added the unreacted mixture of its unreacted starting materials (A) and (B) in a molar ratio of 1:2 in an amount between 1 and 50 % by weight, based on the amount of starting material (C).
26. Method according to claim 23 to 25, **characterised in that** the starting material (C) is tricalcium phosphate, preferably beta-tricalcium phosphate having a phase purity of  $\geq 99$  % by weight, and the unreacted starting materials (A) and (B) are calcium carbonate and calcium hydrogen phosphate.

27. Method according to claim 23 to 26, **characterised in that** the synthesised starting material (C) introduced into the mixture has a particle size smaller than 63  $\mu\text{m}$  with a  $d_{50}$  value in the range from 5 to 20  $\mu\text{m}$ .
28. Method according to one of claims 21 to 27, **characterised in that** the added porosity-causing agents that can be burnt off or that are volatilised have identical or different chemical natures and are added in particle fractions having  $d_{50}$  values in the range from 0.5 to 10  $\mu\text{m}$ , 10 to 100  $\mu\text{m}$  and 100 to 5000  $\mu\text{m}$ .
29. Method according to one of claims 23 to 28, **characterised in that** there is added to the mixture of starting materials (A), (B) and (C), when using the porosity-causing agent ammonium hydrogen carbonate, the particle fraction having a  $d_{50}$  value in the range from 0.5 to 10  $\mu\text{m}$  in an amount of from 1 to 20 % by weight, the particle fraction having a  $d_{50}$  value in the range from 10 to 100  $\mu\text{m}$  in an amount of from 5 to 40 % by weight and the particle fraction having a  $d_{50}$  value in the range from 100 to 5000  $\mu\text{m}$  in an amount of from 1 to 40 % by weight, based on the calculated amount of calcium phosphate.
30. Method according to one of claims 23 to 29, **characterised in that** the compacting of the mixture of the synthesised starting material (C) with the proportion of the mixture of its unreacted starting materials (A) and (B) in a molar ratio of 1:2 and the porosity-causing agents is carried out isostatically under a compression pressure of from 100 to 250 MPa.
31. Method according to one of claims 23 to 30, **characterised in that** the compacted mixture of the synthesised starting material (C) with the mixture of its unreacted starting materials (A) and (B) in a molar ratio of 1:2 and the porosity-causing agent that can be burnt off is heated at a heating rate in the range from 0.5 to 5 K/min to the range from 1373 to 1573 K, is held at that temperature for preferably from 24 to 72 hours and is then cooled back down to room temperature at a cooling rate of from 0.5 to 5 K/min.
32. Method according to claim 29, **characterised in that**, in the controlled temperature treatment, an additional temperature-holding step in the range from 1123 to 1223 K is used.